Center for Economic Institutions
Working Paper Series

CEI Working Paper Series, No. 2002-2

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Working Paper Series

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Saving, Capital Flows, and the Symmetric International Spillover of Industrial Policies *

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June 12, 2002

Abstract

This paper considers the effects of industrial policies in dynamic economy with international trade and monopolistic competition. Special attention is paid to saving, international capital flow, and welfare of all the trading economies. The effects of industrial policies in one country spill over to its trading partners through changes in terms of trade and productivity. Considering such effects, the paper shows that industrial policies in one country increase consumption and saving of all the trading countries. The effects on welfare of foreign countries are identical to those of domestic economy. If the movement of capital among countries is perfect, the movements of consumption over time of all countries also become identical.

*This paper has benefitted from comments from Koichi Hamada, Giuseppe Moscarini, seminar participants at Hokkaido University, Hitotsubashi University, and the Brookings Institution. I am grateful for financial support from the Brookings Instituition.

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[1] INTRODUCTION

Economic development in East Asia, particularly in Japan, features high saving rates and industrial policies by government. The role of the industrial policies in economic development has been analyzed intensively in papers on endogenous growth, and there seems to be a consensus that industrial policies could enhance economic growth if we allow for externality or knowledge spillover. The effects of industrial policies on its trading partners, however, are often conceived to be negative. Tyson and Zysman (1983) argue that government policies in Japan, through promoting saving and giving competitive powers to firms in Japan, have raised the market share of commodities produced in Japan, which have harmed US industries. We can find similar arguments in various papers on "new trade theory".[1]

Industrial policies such as production subsidies and trade policies such as tariffs are often regarded as having identical or similar effects on trading partners because both shift monopoly rents from foreign firms to domestic firms.[2] However, if we are to allow for increasing returns to scale, the two policies should be treated differently. While tariffs create distortions in the world market by setting different prices among trading countries, production subsidies to a sector with imperfect competition could reduce distortions in goods markets and improving productivity. If we regard industrial policies as tools to enhance productivity by utilizing increasing returns to scale, not depriving foreign firms of the market share, combined with the positive effects through reduction of markup, it is no longer clear that such policies harm other countries.

Recently, Abe and Hamada (1999) investigate the effects of industrial policies from

[1] Borrus, Millstein, and Zysman (1983) argue that the Japanese semiconductor industry protected by Japanese government might cause :

"*an irreversible loss of world readership by U.S. firms in the innovation and diffustion of semiconductor technology (*Borrus, Millstein, and Zysman 1983, 142)".

[2] See Brander (1996), for example.

this point of view, and find that the policies have favorable identical effects both on domestic and foreign countries. Their approach is limited to static analysis and does not consider the effects through the changes in capital accumulation and the comparative advantage.

This paper considers the effects of industrial policies that are designed to enhance productivity of a sector with increasing returns to scale in dynamic economies with international trade. Industrial policies in this paper are production subsidies, or equivalently factor payment subsidies to firms with increasing returns to scale. Specifically, the paper adopts the general equilibrium model with imperfect competition discussed in Dixit and Norman (1980) that contains two country, two sectors, multiple production factors, and imperfect competition.[3] Changes made in this paper are as follows: 1) imperfectly competitive goods are used for producing investment goods:[4] 2) the representative consumer in each country has an infinite horizon, maximizes the time separable utility function over time: 3) there are three production factors.[5]

This paper shows that industrial policies in one country increase the welfare not only of the domestic economy but also of its trading partners to the same degree. The basic mechanism behind is the same as in the static model in Abe and Hamada (1999). The positive effects on foreign countries come from two mechanisms. The first is a change in terms of trade. Because of the subsidies to monopolistic firms, the relative price of perfectly competitive goods increases. Since foreign countries produce more

[3]Many recent papers on international trade and economic dynamics adopt externalities such as knowedge spillover. This implies their models contain not only the increasing returns to scale within a firm, but also the scale effects among firms. In order to concentrate on the increasing returns to scale within a firm, the paper abstracts from such externalities.

[4]Farmer and Guo (1993) and Devereux and Lapham (1996) assume that monopolistically competitive firms produce intermediate goods, which is similar to the specification in this paper.

[5]The third assumption is necessary to avoid holding the factor price equalization in the long run in spite of government intervention. Section 3 in this paper dicusses this in detail.

perfectly competitive goods due to the industrial policies, an increase in the price of export goods increases GDP of foreign countries. The second effect is the change in the capital accumulation. Because of the increase in subsidies, productivity for creating capital goods increases, which raises capital accumulation in both countries.[6]

One different and interesting result of this paper from the static model is that the implementation of industrial policies in one country leads two trading economies to converge to different steady states, while in a static model, consumptions of different countries are identical. In the domestic economy, consumption decreases significantly in the beginning, increases eventually, and converges to a new steady state level which is greater than the level before the implementation of the policy. In the foreign country, consumption declines in the beginning to a lesser degree than in the domestic economy, increases shortly after, and converges to the new steady state at which the consumption level is greater than the old steady state level, but smaller than that in the domestic economy. *Although the consumption paths in the two countries are not identical, the changes in the welfare of both countries due to the changes in the two consumptions paths are shown to be identical.* If we allow for perfect international capital movement, the difference of consumption paths in the two countries disappears.

The effects of policies on saving are similar to those on consumptions. Industrial policies in country A increase both saving in countries A and B, while saving in country A increases more than in country B. The result suggests that a country with significant industrial policies has higher saving rate than other countries, although the industrial policies are not designed to increase saving. As before, the perfect international capital movement brings identical changes in saving among countries.

[6]Because this paper adopts the specification developed by Dixit and Stiglitz (1977), an improvement of productiviy appears as an increase in the number of differentiated goods, and not in the scale of production that is analyzed by Abe and Hamada (1999).

The next section describes the base model. The third section considers an economy with two production factors. The fourth section examines an economy with three production factors. The fifth section considers an economy in which capital can move among countries. The last section provides concluding remarks.

[2] THE BASE MODEL

Suppose there are two identical countries, A and B.[7] Each country has two sectors, a perfectly competitive sector that produces consumption goods with linear homogenous technology, a monopolistically competitive sector in which firms produce differentiated goods with increasing returns to scale. The price of the consumption goods is fixed at unity without loss of generality. The differentiated goods are intermediate goods that are used to produce physical capital. Production factors are untradable internationally.

In each country, consumers share the same preferences and maximize utility over an infinite horizon. Specifically, the representative consumer in each country is assumed to have the time separable utility function with infinite horizon as follows,

$$\sum_{t=0}^{\infty}\left(\frac{1}{1+\rho}\right)^{t}u\left(C_{s,t}\right). \tag{1}$$

$C_{s,t}$ is the consumption in country s at time t. ρ is the discount rate. This consumer purchases both investment and consumption goods in a free international market and creates physical capital from the intermediate goods with linear homogenous technology as follows:[8]

$$K_{s,t+1}=I_{s,t}+\left(1-\delta\right)K_{s,t}, \tag{2}$$

[7] Because of the symmetry among countries before the implementation of industrial policies, international trade occurs not because of the difference in comparative advantages, but because of "love of variety" analyzed by Krugman (1980) and Markusen (1981).

[8] Alternatively, we can assume that there exists a perfectly competitive firm which produces physical capital from the intermediate goods and the consumer purchases the capital from the firm.

$$I_{s,t}=\left(\int_0^{n_{A,t}} I_{(i,A),s,t}^{\frac{\varepsilon-1}{\varepsilon}}di+\int_0^{n_{B,t}} I_{(i,B),s,t}^{\frac{\varepsilon-1}{\varepsilon}}di\right)^{\frac{\varepsilon}{\varepsilon-1}},\varepsilon>1. \tag{3}$$

$I_{s,t}$ is the gross investment produced from the intermediate goods.[9] $I_{(i,s'),s,t}$ is a differentiated commodity produced in country s' and purchased by the consumer in country s at time t. n_s $(s=A,B)$ is a number of differentiated goods in country s, which are determined endogenously in the model. δ is the depreciation rate. The budget constraint the consumer faces is as follows:

$$C_{s,t}+P_tI_{s,t}=r_{s,t}K_{s,t}+Q_{s,t}\overline{Z}+\Lambda_{s,t}-Tax_{s,t}, \tag{4}$$

where

$$P_t=\left(\int_0^{n_{A,t}} p_{(i,A),t}^{1-\varepsilon}di+\int_0^{n_{B,t}} p_{(i,B),t}^{1-\varepsilon}di\right)^{\frac{1}{1-\varepsilon}}. \tag{5}$$

$r_{s,t}$, $\Lambda_{s,t}$, $Tax_{s,t}$ are rental costs of capital, shares, and lump-sum tax in country s, respectively. $\overline{Z}$ is a vector of endowments of other production factors that are constant over time. $\overline{Z}$ can consist of labor, land, and other production factors that are provided by the consumer inelastically. $Q_{s,t}$ is a vector of the factor prices corresponding to $\overline{Z}$. $p_{(i,s),t}$ is the price of differentiated goods i, produced in country s at time t. P_t is the aggregate price index. Using the Lagrangian with a multiplier, $\lambda_{s,t,}$, the first order conditions for the utility maximization problem can be written as[10]

$$(1+\rho)\,\lambda_{s,t+1}=\left(\frac{r_{s,t}}{P_t}+1-\delta\right)\lambda_{s,t}, \tag{6}$$

$$\frac{\lambda_{s,t}}{P_t}=u'\left(C_{s,t}\right). \tag{7}$$

In the perfectly competitive sector, firms maximize profits at each time. The firms are assumed to have a neoclassical production function that is differentiable, linear

[9] This functional form is taken from Dixit and Stigltitz (1977). This particular form gives us a factor demand function for each differentiated commodity that has constant price elasticity, $-\varepsilon$.

[10] See the Appendix for the derivations.

homogeneous, and satisfies the Inada condition. Due to the linear homogeneity, we can regard the sector as a single firm that maximizes its profit. Let's denote the production function as follows,

$$x_{s,t} = x\left(K_{x,s,t}, Z_{x,s,t}\right). \tag{8}$$

$K_{x,s,t}$ and $Z_{x,s,t}$ are capital and other production inputs in the sector at time t.[11]

In the monopolistically competitive sector, each firm has to abandon a part of its output as the fixed costs to keep the operation[12].

A monopolistically competitive firm i in country s that produces goods $\widetilde{y}_{(i,s),t}$ faces a demand function with a constant price elasticity, $-\varepsilon$. We assume that after paying the fixed cost, the firm can use linear homogeneous technology such as,

$$\widetilde{y}_{(i,s),t} = \widetilde{y}\left(K_{(i,s),t}, Z_{(i,s),t}\right), \tag{9}$$

where $K_{(i,s)}$ and $Z_{(i,s),t}$ are capital and other production inputs of firm i respectively.

The cash flow of the firm i is,

$$T_{s,t}p_{(i,s),t}y_{(i,s),t} - r_{s,t}K_{(i,s),t} - Q_{s,t}Z_{(i,s),t} \tag{10}$$

where $y_{(i,s)}$ is the amount of products the firm can sell. $y_F = \widetilde{y}_{(i,s),t} - y_{(i,s),t}$ is the amount of the outputs that must be incurred as fixed costs. $T_{s,t}$ is the subsidy to the output.[13] The government finances its expenditures for the subsidy by lump-sum taxation on consumers in its own country. The world goods market is integrated, so

[11] $Z_{x,s,t}$ can consist of labor, land, and other production factors. Latter sections in this paper specifies the contents of $Z_{x,s,t}$.

[12] For the treatment of the fixed costs, we follow Rotemberg and Woodford (1995). Another way to treat the fixed costs is to introduce entry costs. We avoid the latter case to keep the model simple.

[13] Whether the policies are subsidies or not depends on the size of $T_{s,t}$. If $T_{s,t}$ is greater than unity, that will be subsidies, otherwise, that will be taxation.

that the firm cannot set different prices for its product in different countries.[14] The first order conditions for the profit maximization with respect to capital itakes the form

$$\frac{(\varepsilon-1)}{\varepsilon}p_{(i,s),t}\frac{\partial\widetilde{y}_{(i,s),t}}{\partial K_{(i,s),t}}=\frac{r_{s,t}}{T_{s,t}}. \tag{11}$$

In both commodity markets, there is free trade between two countries. The market clearing conditions are as follows:[15]

$$C_{A,t}+C_{B,t}=x_{A,t}+x_{B,t}, \tag{12}$$

$$I_{(i,s),A,t}+I_{(i,s),B,t}=y_{(i,s),t}, \quad where \quad s=(A,B)\,. \tag{13}$$

The capital market clearing conditions is given by

$$n_{s,t}K_{(i,s),t}+K_{x,s,t}=K_{s,t}. \tag{14}$$

The market equilibrium in this economy is defined as follows,

Definition 1 *The market equilibrium*

Given the tax and subsidy rates, the market equilibrium is a series of sets of $\{\ Z_{x,s,t}, K_{x,s,t}, I_{s,t}, C_{s,t}, n_{s,t}, Q_{s,t}, r_{s,t}, x_{s,t}, P_t, K_{s,t},$
$\left(Z_{(i,s),t}, K_{(i,s),t}, y_{(i,s),t}, \widetilde{y}_{(i,s),t}, p_{(i,s),t}, I_{(i,s),A,t}, I_{(i,s),B,t}\right)_{i=0}^{n_{s,t}}\ \}_{t=0}^{\infty}$

$s=A,B$, *which satisfies the following conditions for both* $s=A,B$;

1) $\left(C_{s,t}, I_{s,t}, K_{s,t}, \left(I_{(i,s),A,t}, I_{(i,s),B,t}\right)_{i=0}^{n_{s,t}}\right)_{t=0}^{\infty}$ *solves the consumer's problem;*

2) $(Z_{x,s,t}, K_{x,s,t})_{t=0}^{\infty}$ *solves the profit maximization problem for the perfectly*

[14] This assumption is not restrictive at all in the model. Because we assume constant elasticity, even if the firm can freely choose the price level in different countries, the firm will set the same prices in all countries to maximize the profits.

[15] We assume that the government does not consume or waste resouces, so that all the products sold will be used by consumers.

competitive firms;

3) $\left(\left(Z_{(i,s),t}, K_{(i,s),t}, y_{(i,s),t}, \widetilde{y}_{(i,s),t}, p_{(i,s),t}\right)_{i=0}^{n_{s,t}}\right)_{t=0}^{\infty}$ *solves the profit maximization problem for the monopolistically competitive firms*

4) $\left(n_{s,t}, Q_{s,t}, r_{s,t}, L_{(i,s),t}, K_{(i,s),t}, y_{(i,s),t}, \widetilde{y}_{(i,s),t}, p_{(i,s),t}\right)_{t=0}^{\infty}$ *satisfies the zero profit condition;*

5) all the markets, i.e., capital, other factors for productions, and goods markets are cleared;

6) both P_t *and* $I_{s,t}$ *satisfy the aggregate formula.*

In a set of market equilibria, we concentrate on a symmetric equilibrium within a country in which all the monopolistic firms set the same price in each country. The price can be different among countries. In a symmetric equilibrium, the aggregate price index becomes

$$P_t = \left(n_{A,t} p_{(i,A),t}^{1-\varepsilon} + n_{B,t} p_{(i,B),t}^{1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}}. \tag{15}$$

In the symmetric equilibrium, the individual budget constraint can be written as the following equation,[16]

$$C_{s,t} + P_t I_{s,t} = n_{s,t} p_{(i,s),t}\left(\widetilde{y}_{(i,s),t} - y_F\right) + x_{s,t}. \tag{16}$$

The above equation shows that the total expenditures including saving must be equivalent to the total value of productions minus fixed cost payments.

[16] The budget constraint for the government,

$$Tax_{s,t} = \frac{T_{s,t} n_{s,t}}{T_{s,t} - 1}\left(r_{s,t} K_{(i,s),t} + Q_{s,t} Z_{(i,s),t}\right)$$

is used for the derivation.

The model abstracts from public debts, which is not restrictive because Barro-Ricardo's equivalent theorem holds in the model.

Notice that at the steady state, the rental cost divided by the aggregate price index is equal to the sum of the discount rate and the depreciation rate,

$$\rho + \delta = \frac{r_s}{P}. \tag{17}$$

Because ρ, δ, and P are the same in both countries, the rental costs of capitals are identical in both countries at the steady state.

It is also worth paying attention to the fact that the equilibrium level of the production scale of each monopolistic firm becomes as follows:[17]

$$y_{(i,s)} = (\varepsilon - 1)\, y_{F.} \tag{18}$$

The interpretation of the above formula is straightforward. Assuming free entry and exit, the equilibrium level of profit is zero. This implies that the profit after paying variable costs, $\frac{1}{\varepsilon} p_{(i,s),t} \widetilde{y}_{(i,s),t}$, should be equivalent to fixed costs payments, $p_{(i,s),t} y_{F.}$ The above formula suggests that the production scale does not depend on factor prices or output prices. This implies the output level of each monopolistic firm does not depend on the subsidy rates, either.

[3] A CASE WITH TWO PRODUCTION FACTORS

Suppose there are two production factors, capital and labor, as in Dixit and Norman (1980). That is, Z consists of labor forces, L, only. The amount of labor endowment, $\overline{L}$, is fixed over time and is provided by the consumer inelastically. Let's denote the wage as $w_{s,t}$ in country s at time t. The production functions in both sectors become as follows:

$$x_{s,t} = x\left(K_{x,s,t}, L_{x,s,t}\right), \tag{19}$$

[17] See Abe and Hamada (1999) for details. Such constancy also occurs in the original model of monopolistic competition by Dixit and Stiglitz (1977) as well.

$$\widetilde{y}_{(i,s),t} = \widetilde{y}\left(K_{(i,s),t}, L_{(i,s),t}\right). \tag{20}$$

Now, suppose that in country A, the government increases the subsidy rate by one percent from unity permanently. In country B, the government does not give subsidies, so that T_B is fixed at unity over time. In the economy with only two production inputs, such industrial policies have serious effects on both countries in the long run. Because the changes in the rental costs are the same in both economies at the steady state, due to the linear homogenous technology in the perfectly competitive sector, the changes in the wage rates are also equalized. In other words, the factor equalization holds in the economy in spite of the intervention by the government in the long run. In such a case, the monopolistically competitive firms in country B are not able to conduct their production due to the changes in the relative prices. Formally, we can state it as follows,

Proposition 1

In a 2-2-2 model, an introduction of the subsidy in country A forces country B to specialize in producing perfectly competitive goods in the long run.

(**Proof**)

See the Appendix. ■

The above proposition implies that an infinitesimal permanent increase in the subsidy rate in country A creates discrete changes in the market equilibrium in the long run.[18] If the industrial policies are not permanent but temporal, the changes in the market equilibrium becomes infinitesimal, so that we can analyze the effects through

[18]Mathematically, we can state that the dynamic system with two predetermined variables and two

observing the transitional dynamics. In order to see the transition, we have to specify functional forms for preferences and technology. I use CRRA for preferences and Cobb-Douglas for technology,

$$u\left(C_{s,t}\right)=\frac{C_{s,t}^{1-\sigma}}{1-\sigma}, \tag{21}$$

$$x_{s,t}=A_{x}K_{x,s,t}^{\gamma}L_{x,s,t}^{1-\gamma}, \tag{22}$$

$$\widetilde{y}_{(i,s),t}=A_{y}K_{(i,s),t}^{\alpha}L_{(i,s),t}^{1-\alpha}. \tag{23}$$

The parameter values are set at

$$\alpha=0.33, \quad \gamma=0.2, \quad \delta=0.06, \quad \rho=0.03, \quad \varepsilon=3, \quad \sigma=3. \tag{24}$$

Since $\alpha>\gamma$, the monopolistic firms have more capital intensive technology than the perfectly competitive firms. There has been no agreement on the value of ε, the elasticity of demand. For example, Rotemberg and Woodford (1994) set $\varepsilon=3.5$, while Farmer (1993) assumes $\varepsilon=2.4$. The greater ε is, the closer to the perfect competition the economy becomes. Therefore, the value of ε is essential for the role of the market imperfection in the economy. I set $\varepsilon=3$, which is the mean of the two values. Other variables are taken from Barro and Sala-I-Martin (1995). For the temporal shocks of the industrial policies, I assume that the government in country A increases the subsidy rate at time 1 and gradually decreases it. Specifically, I assume that the subsidy rate follows an AR1 process such as,

$$T_{s,t+1}-1=\theta\left(T_{s,t}-1\right)+\epsilon_{s,t}. \tag{25}$$

unpredetermined variables has two unstable roots and one unit root. The predetermined variables are capital in both countries. The unpredetermined variables are marginal utility of consumption in both countries. See the Appendix for details.

$\epsilon_{s,t}$ is a shock in the subsidy rate at time t, which represents a change in the industrial policies in country s. θ determines the length of the adjustment in the subsidy rate. I set $\theta = 0.9$ in the following simulation so that we can see the shocks visually.

Other parameters such as y_F, A_x, A_y, and $\overline{L}$, the endowment of labor forces, do not affect the result, so that they are left unspecified. The Appendix contains the derivations of the dynamic system of this economy and procedures to solve the system. In the following numerical calculation, I assume that initially the economy is at the steady state. At time one, the government in country A raises the production subsidy by one percent and gradually decreases it, while the other government does not implement industrial policies. In other words, I set $\epsilon_{s,t} = 1$ for $(s,t) = (A,1)$, otherwise $\epsilon_{s,t} = 0$. Figure 1 and 2 show impulse-responses of consumption (C_s), saving (I_s), the number of differentiated goods (n_s), rental cost of capital (r_s), real rental cost (r_s/P), total capital level (K_s), production level of perfectly competitive goods (x_s), saving rate($SavingRate_s$), and the price of differentiated goods (p_s) in country A ($s = a$) and B ($s = b$), respectively. The saving rate in country s is defined as follows;

$$Saving \quad Rate = \frac{P_t I_{s,t}}{C_{s,t} + P_t I_{s,t}}. \tag{26}$$

The denominator is the income of the representative consumer in country s at time t. The numerator is the expenditure for saving.

The x-axes in the figures show the time. The y-axes are the rate of changes of each variable from the initial points. For example, subfigure (1) in Figure 1 shows that in the beginning, consumption in country A decreases by one percent from the original steady state level due to the one percent increase in the subsidies in country A. As time passes, the consumption increases and converges to the new steady state that is higher than the initial level by 0.2 percent. We can observe permanent increases in total capital level, saving rate, and consumption in country A, while, in country B, such variables decrease permanently. Despite the short run changes in the industrial policies, the effects of the policies last eternally in many variables. In other words, there exists "hysteresis" in the economy. The consumption in country A increases at the cost of the consumption in country B, which coincides with arguments in existing literature on "new trade theory".[19]

As Lahiri and Ono (1994) discuss, the number of production factors and the number of production sector are crucial for the factor price equalization theorem. Without government intervention, if the number of production factor is smaller or equal to the number of sector with perfect competition, the factor price equalization theorem holds trivially. Using a static model, Lahiri and Ono (1994) find that even if one of the sectors is monopolistically competitive, as long as entry and exit are free and if no factor intensity reversal exits, the equalization theorem holds. In a dynamic model, we have to distinguish the equalization in long-run and short-run. As is shown in this section, at the steady state, the rental cost of capital in each country is identical because, at the steady state, the real return of capital should be equivalent to the sum of time preference and discount rate. If there exist only two production factors, since one of the factor prices is determined by exogenous parameters, there is only one degree of freedom for the factor prices that can be determined in the factor markets. Since we assume that the perfectly competitive sector has linear homogeneous technology, in spite of government intervention, the factor price equalization holds trivially in the long run. Such a trivial equalization no longer occurs if we allow for an additional factor of production.

If we allow for three production factors, an increase in subsidy in A increases rental costs in A, decreases in B as in the economy with two production factors. However, because one of the factors other than capital is generally used more intensively in production of the differentiated goods, as the production of the monopolistic goods

[19] See Brander (1996), for example.

increases, the shortage of the factor which is used in produciton of differentiated goods intensively makes the production of the commodities more costly. Therefore, there is a force which decreases the production of the monopolistic products, which lets the economy to converge to the original steady state.[20]

In the next section, an economy with three production factors is analyzed, which exhibits opposite movements of consumption and capital in country B.

[4] A CASE WITH THREE PRODUCTION FACTORS

In this section, we consider an economy with three different kinds of production factors, capital, labor, and land.[21] Let's denote them as K, L, and H. That is, $Z = (L, H)$. The factor prices of them are denoted by r, w_L, w_R, respectively. The endowments of labor and capital are fixed over time. The consumer's budget constraint at time t can be written as follows,

$$C_{s,t} + P_t I_{s,t} = r_{s,t} K_{s,t} + w_{L,s,t} \overline{L} + w_{R,s,t} \overline{H} + \Lambda_{s,t} - Tax_{s,t}. \tag{27}$$

The production functions in both sectors become

$$x_{s,t} = x\left(K_{x,s,t}, L_{x,s,t}, H_{x,s,t}\right), \tag{28}$$

$$\widetilde{y}_{(i,s),t} = \widetilde{y}\left(K_{(i,s),t}, L_{(i,s),t}, H_{(i,s),t}\right). \tag{29}$$

Contrary to the previous case with only two production factors, the factor price equalization does not hold in the long run if we allow for government intervention,

[20]If all the production factors except for capital have the same intensity between both products, hysteresis appears even if there are many production factors.

[21]Instead of land, we can introduce two different kinds of labor forces such as skilled labor and unskilled labor as long as they are not perfect substitutes in production.

which creates more gradual changes in the market equilibrium caused by the industrial policies.

To see the effects of permanent changes in the subsidy rate, I assume that the government in country A increases the subsidy rate by one percent at time one and leaves it unchanged after the implementation. The other government does not change the subsidy rate over time.

As in the previous section, we can use an AR1 process to describe the industrial policies. Suppose that the subsidy rate in country s follows an AR1 process as,

$$T_{s,t+1} - 1 = \theta \left(T_{s,t} - 1\right) + \epsilon_{s,t}, \tag{30}$$

with $\theta = 1$ and $\epsilon_{s,t} = 1$ for $(s,t) = (A,1)$, otherwise $\epsilon_{s,t} = 0$.

First, we show that even if the market equilibrium is inefficient, production is conducted on the production possibility frontier. In other words, x-inefficiency does not occur.

The intratemporal production possibility frontier in country s is defined as follows:

Definition 1: The Intratemporal Production Possibility Frontier

The intratemporal production possibility frontier at time t in country s in a symmetric case is a set of $\left(x_{s,t}, y_{(i,s),t} n_{s,t}^{\frac{\varepsilon}{\varepsilon-1}}, K_{s,t}\right)$ *such that*

$$x_{s,t} = \Phi\left(y_{(i,s),t} n_{s,t}^{\frac{\varepsilon}{\varepsilon-1}}, K_{s,t}\right) \quad \textit{where} \tag{31}$$

$$\begin{aligned} &\textit{given } y_{(i,s),t} n_{s,t}^{\frac{\varepsilon}{\varepsilon-1}},\ x_{s,t} = Max \quad x_{s,t} \textit{ subject to} \\ &\qquad \widetilde{y}_{(i,s),t}\left(K_{(i,s),t}, L_{(i,s),t}, H_{(i,s),t,}\right) - y_F \geq y_{(i,s),t} \\ &\qquad \overline{L} \geq n_{s,t} L_{(i,s),t} + L_{x,s,t}, \\ &\qquad \overline{H} \geq n_{s,t} H_{(i,s),t} + H_{x,s,t}, \\ &\qquad K_{s,t} \geq n_{s,t} K_{(i,s),t} + K_{x,s,t} \end{aligned}$$

$$x\left(K_{x.s,t}, L_{x,s,t}, H_{x,s,t}\right) \geq x_{s,t}.$$[22]

The PPF shows the maximum amount of aggregated products, $x_{s,t}$,given the amount of $y_{(i,s),t}n_{s,t}^{\frac{\varepsilon}{\varepsilon-1}}$.[23]

In order to avoid dealing with multiple equilibria, the following assumption is imposed on the frontier.

Assumption 1

There exists a unique solution to the system of first order conditions for the maximization problem in PPF, which actually gives the maximum.[24]

Because the market equilibrium is inefficient due to monopoly power, whether the market equilibrium is on the PPF is unclear. The following lemma, however, assures that the market equilibrium is on the frontier.

Lemma 1 :

Under Assumption 1, the world wide market equilibrium is on the intratemporal production possibility frontier in each country.

Proof. See The Appendix . ■

At first glance, it may seem obvious because, as long as the government gives subsidies to both factors, the ratio of marginal product values in both sectors is the

[22] In addition, all the endogenous variables should be non-negative. We assume the existence of an interior solution so that we can avoid consideration of corner solutions.

[23] See Abe and Hamada (1999b) for detailed discussion on this frontier.

[24] In the case of classical economy without increasing returns to scale, some assumptions such as strict convexity in production and the absence of factor intensity reversal would guarantee the above characteristics. In our setting with increasing returns, the above assumption basically requires both the exclusion of factor intensity reversal and weak non-convexity in technology.

same, which usually excludes x-inefficiency in an economy without monopoly power. Such is not the case in our model, however, because there is an additional variable, the number of firms, which no private agents control in their maximization problems in the market equilibrium.

Without monopoly power, the slope of the frontier in the market equilibrium is equivalent to the marginal rate of substitution. In our model, however, due to the monopoly power, such equivalence no longer holds. The slope of the frontier in the market equilibrium depends on the demand elasticity. Specifically, the slope becomes as follows:

Lemma 2

Under Assumption 1, the partial derivatives of the intratemporal production possibility frontier in the market equilibrium are as follows:

$$\frac{\partial \Phi\left(y_{(i,s)} n_s^{\frac{\varepsilon}{\varepsilon-1}}, K_{s,t}\right)}{\partial y_{(i,s)} n_s^{\frac{\varepsilon}{\varepsilon-1}}} = -\frac{T\left(\varepsilon-1\right)}{\varepsilon} n^{\frac{1}{1-\varepsilon}} p_{(i,s)}, \tag{32}$$

$$\frac{\partial \Phi\left(y_{(i,s)} n_s^{\frac{\varepsilon}{\varepsilon-1}}, K_{s,t}\right)}{\partial K_{s,t}} = \frac{\partial x_{s,t}}{\partial K_{x,s,t}}. \tag{33}$$

Proof. See the Appendix . ■

The economic interpretation of the first equation, (32) , is straightforward. The slope of the production possibility frontier is different from the aggregate price index due to the markup, $\frac{\varepsilon}{\varepsilon-1}$. The subsidy policy changes the slope by changing the costs of the commodities produced in the monopolistically competitive sector.

Under these settings, we can prove the following proposition .

Proposition 2

Suppose Assumption1 is satisfied. Also, suppose that the government in country A introduces subsidies to its domestic monopoly sector. Then, the changes in the welfare of both countries are identical. That is, the following equation holds;

$$\sum_{t=0}^{\infty}\left(\frac{1}{1+\rho}\right)^{t} u'\left(\overline{C}\right) dC_{A,t} = \sum_{t=0}^{\infty}\left(\frac{1}{1+\rho}\right)^{t} u'\left(\overline{C}\right) dC_{B,t}, \tag{34}$$

where $\overline{C}$ is the consumption level at the steady state before the implementation of the industrial policies in country A. $dC_{s,t}$ is the deviation of the consumption from the steady state level, $\overline{C}$ in country s at time t.

Proof. See the Appendix. ■

The intuition behind Proposition 2 can be explained as follows. The welfare gains from the industrial policies come from the reduction in the wedge between the marginal costs and the prices in the differentiated goods produced in country A. The effects are amplified by the expansion in the total number of differentiated goods produced in both countries. Because of the free trade, consumers in both countries can get benefits to the same degree from the changes. Besides, there are distributional effects through changes in production. Due to the industrial policies, country A will produce more differentiated goods than country B. Because of the markup, the marginal costs of the differentiated commodities are greater than that of perfectly competitive goods. Therefore, by producing more differentiated goods, country A would seem to get more gains than country B. However, in our model, it is not the case. The intratemporal production possibility frontier in the model is defined in $\left(x, y_i n^{\frac{\varepsilon}{\varepsilon-1}}\right)$ space. The movement of the market equilibrium due to the changes in the subsidy rate in country A occurs along the frontier. A decrease in x in country A causes smaller increase in n than a case with fixed number of firms in which the frontier is defined in (x, ny_i) space. In the model, even though the frontier is defined in $\left(x, y_i n^{\frac{\varepsilon}{\varepsilon-1}}\right)$ space, GDP is defined in (x, ny_i) space. This implies that by shifting the production to the upper direction on the frontier, country A loses its GDP. Because of the specification of the model, the degree of returns to the variety is equivalent to the degree of markup, $\frac{\varepsilon}{\varepsilon-1}$, which equalizes the loss and the benefit for country A through distributional effects. In country B, the distributional effects disappear because of the same mechanism. Therefore, the only remaining effects are the reduction of the distortions and the expansion of the total number of differentiated goods, which improve the welfare of two countries to the same degree.

Numerical Example

In order to see the changes in consumption, capital, welfare, and other variables due to the industrial policies in country A, we need to solve the system numerically. Similar to the previous section, we assume Cobb-Douglas production functions, which have the forms as follows;

$$x_{s,t} = A_x K_{x,s,t}^{\gamma} L_{x,s,t}^{\phi} H_{x,s,t}^{1-\gamma-\phi}, \tag{35}$$

$$\widetilde{y}_{(i,s),t} = A_y K_{(i,s),t}^{\alpha} L_{(i,s),t}^{\beta} H_{(i,s),t}^{1-\alpha-\beta}. \tag{36}$$

The utility function is CRRA as before. The parameter values are set at

$$\alpha = 0.33, \quad \beta = 0.2, \quad \gamma = 0.3, \quad \phi = 0.4, \quad \delta = 0.06, \quad \varepsilon = 3, \quad \rho = 0.03. \tag{37}$$

Figures 3 and 4 show impulse-responses of consumption (C_s), saving (I_s), the number of differentiated goods (n_s), rental cost of capital (r_s), the real rental cost (r_s/P), total capital level (K_s), production level of perfectly competitive goods (x_s), saving rate$(SavingRate_s)$, and the price of differentiated goods (p_s) in country A $(s = a)$ and B $(s = b)$, respectively when the government in country A increases the subsidy rate by one percent at time one, that is, $\epsilon_{s,1} = 1$. The movements of consumption and saving in country A are similar to those in the previous case with two production factors. The rental cost of capital in country A increases in the beginning. The mechanism behind is as follows. Since the monopolistic firms are more capital intensive, the subsidies to the firms increase the capital demand, which increases the price of capital. Because of the surge in the rental cost, the consumption in country A decreases in the beginning. This implies that the consumer increases saving, I_A. Because of the increase in the saving, the capital is accumulated in country A. The accumulation is amplified by the increase in the total number of differentiated goods, $n_A + n_B$, in the world because there are increasing returns to the variety in the production function of the physical capital, (3).

In country B, the movements of consumption and capital are very different from the previous section with two production factors. The industrial policies in country A decrease the price of the differentiated goods, which leads country B to produce more perfectly competitive goods. Because we assume that the monopolistic firms are more capital intensive, the rental cost decreases in country B. However, in spite of the decrease in the rental cost, because of the increase in the total number of the differentiated goods, the real rental cost increases in country B, as well as in country A. Also because of the increase in the variety, the effective amount of saving, $I_{s,t}$, increases, which raises the accumulation of capital in country B. Because of the accumulation of capital, the production resources also increase, which will raise the consumption level.

The changes in the utility levels from the steady state level can be obtained by calculating

$$dU_s = \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho} \right)^t \overline{C}_s^{1-\sigma} \left(\widehat{C}_{s,t} \right)$$
$$= \overline{C}_s^{1-\sigma} \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho} \right)^t \left(\widehat{C}_{s,t} \right) \qquad (38)$$

where $\overline{C}_s$ is the consumption level before the implementation of the industrial policies. Under the parameter values specified above, the changes in welfare of both countries are as follows:[25]

$$\sum_{t=0}^{\infty} \left(\frac{1}{1+\rho} \right)^t \left(\widehat{C}_{A,t} \right) = 3.759 > 0, \qquad (39)$$

$$\sum_{t=0}^{\infty} \left(\frac{1}{1+\rho} \right)^t \left(\widehat{C}_{B,t} \right) = 3.759 > 0. \qquad (40)$$

As is stated in Proposition 2, the changes in the welfare of both countries are identical.

Subfigures (4) in Figures 3 and 4 show that the rental costs of capital moves differently in two countries. Since the rental cost in country A is greater than that in country B, if the capital market is open, or, if we allow for foreign direct investment, the consumer in country B has incentive to invest in firms in country A because of the higher returns. Next section explores the effects of the industrial policies when capital markets are open to foreign investors.

[5] A CASE WITH INTERNATIONAL CAPITAL MOVEMENT

This section considers an economy in which capital can move among countries. Basically, the model in this section is the same as that in the previous section which

[25] Since the transitional dynamics are derived from the linearized system, it is consistent to use linear approximation for calculating the changes in welfare. It may contain errors that are of second order.

contains three production factors. The only difference is that consumers can invest to foreign countries. Suppose there exists an international bank that collects resources from consumers in each country and lends them to firms. That is, the consumer in country s ($s = A, B$) does not lend the capital directly to firms in country s but opens an account in the bank. The bank offers two different accounts to the consumer in country s, foreign account and domestic account. The balance in the domestic account is invested in the firms in the domestic economy. The balance in the foreign account is invested in the other country.[26] If capital can move among countries without costs, the two accounts are identical for the consumers in terms of the returns. However, if the costs for such mobility exist, the returns from investing in foreign firms include the costs, so that the returns are smaller than those of the domestic account. I assume that the bank earns zero profits.

Define $K_{A,B,t}$ as the amount of the balance in the foreign account holding by the consumer in country A. If the consumer in country A adds $V_{A,B,t}$ amount of resources to the foreign account at the bank at time t, in the next period, the amount of balance becomes[27]

$$K_{A,B,t+1} = (1 - \varphi(V_{A,B,t}))\, V_{A,B,t} + (1 - \delta)\, K_{A,B,t}, \tag{41}$$

where $\varphi(V_{A,B,t})$ is an increasing function of $V_{A,B,t}$ that satisfies

$$\varphi'(V_{A,B,t}) \geq 0, \tag{42}$$

$$\varphi(0) = 0. \tag{43}$$

If $\varphi(V_{A,B,t})$ is always zero, the capital mobility is perfect.

If the consumer in country A adds $V_{A,A,t}$ amount of investment goods to the do-

[26] The total number of the accounts offered by the bank is four. The balance of each account can be negative as long as the total balance for one consumer is positive.

[27] I include δ, the depreciation rate, to keep the consistency with the previous models.

mestic account at the bank, the balance in the account becomes

$$K_{A,A,t+1} = V_{A,A,t} + (1-\delta)\, K_{A,A,t}. \tag{44}$$

The total capital the bank lends to country A is

$$K_{A,t} = K_{A,A,t} + K_{B,A,t}. \tag{45}$$

The total amount of the changes in the lending to the bank by the consumer in country s is equal to the amount of investment goods produced by the consumer, that is,

$$I_{s,t} = V_{s,A,t} + V_{s,B,t}. \tag{46}$$

The gross return of the account for country s is equivalent to the rental cost of capital in country s, that is $r_{s,t}$. The consumer in country A solves the maximization problem as follows:

$$Max \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho}\right)^{t} u\left(C_{s,t}\right), \tag{47}$$

s,t,

$$K_{A,B,t+1} = \left(1-\varphi\left(V_{A,B,t}\right)\right) V_{A,B,t} + (1-\delta)\, K_{A,B,t}, \tag{48}$$

$$K_{A,A,t+1} = V_{A,A,t} + (1-\delta)\, K_{A,A,t}, \tag{49}$$

$$C_{A,t} + P_t I_{A,t} = r_{A,t} K_{AA,t} + r_{B,t} K_{AB,t} + w_{L,A,t}\overline{L} + w_{R,A,t}\overline{H} + \Lambda_{A,t} - Tax_{A,t}, \tag{50}$$

$$I_{A,t} = V_{A,A,t} + V_{A,B,t}. \tag{51}$$

Because of the costs for transferring the resources among countries, the consumer invests in the foreign country only when the return from that country is higher than the domestic rate. Before the implementation of the industrial policies, everything is symmetric in the two countries, so that in the beginning, the consumers own all the domestic capital and no foreign assets.

Suppose that the mobility cost is a linear function of the investment, that is,

$$\varphi(V) = zV, \tag{52}$$

where $z \geq 0$.

As in the previous section, I assume Cobb-Douglas technology,CRRA utility function, and the same parameter values as in the previous section, that is,

$$\alpha = 0.33, \quad \beta = 0.2, \quad \gamma = 0.3, \quad \phi = 0.4, \quad \delta = 0.06, \quad \varepsilon = 3, \quad \rho = 0.03. \tag{53}$$

Figures 5 and 6 show the impulse-responses of the variables due to the changes in the subsidy rate in country A with $z = 1000$. Subfigure (7) shows the movements of investment in the other country.[28] (11) and (12) illustrate the adjustments of the factor prices of labor and land, respectively. Because the adjustment costs for investing in the other country are high, the movements of the variables are quite similar to those in the previous case in which capital cannot move among countries. As subfigure (7) shows, the movement of capital among them is quite small.

Figures 7 and 8 illustrate the impulse-responses when $z = 0.000001$, where the capital can move among countries without significant costs. In this case, because capital is close to moving freely, the movements of the rental price in each country, subfigures (4), are very similar to each other. The difference in the beginning period comes from the assumption that capital can move one period after the implementation of the industrial policies in country A

[28] Before the implementation of the industrial policies, the economy is at the steady state at which the balance in the foreign account is zero. This implies both $I_{A,B}$ and $I_{B,A}$ are zero before the changes in the policies. Therefore, the y-axes for subfigure (7) are the amount of the deviations of $I_{A,B}$ and $I_{B,A}$ from zero, rather than the rate of deviations from the steady state level.

Subfigures (1) in Figures 7 and 8, which show the movements of consumption in each country, suggest that as the costs of adjustment become zero, the difference in consumption among countries vanishes. Formally, we can state it as follows:

Proposition 3

Suppose $\varphi(V) = 0$ for all V. *Also, suppose the government in country A introduces subsidies to its domestic monopoly sector. Then, the consumption paths in both countries are identical, that is,*

$$dC_{A,t} = dC_{B,t}, \quad for \quad all \quad t. \tag{54}$$

where $dC_{s,t}$ *is the deviation of the consumption from the steady state level,* $\overline{C}$ *in country s at time t.*

Proof. See the Appendix. ■

Due to the identity of two consumption paths, the changes in welfare of both counties are also identical. Notice that although the movements of consumption in each country are identical, the movements of productions and factor prices are not identical. In country A, wages decrease because the monopolistic firms are assumed to be less labor intensive than the perfectly competitive firms. In country B, wages increase because the country produces more perfectly competitive goods due to the changes in the industrial policies in country A.

[6] CONCLUDING REMARKS

The paper has considered the effects of industrial policies in one country in dynamic economies with two-sectors, multiple-factor, and two-country, in which the source of scale economies is derived from a fixed cost. According to conventional views, industrial policies in one country often damage its trading partners through an increase in the market share of the commodities protected. By considering the role of industrial policies as enhancing productivity through utilizing increasing returns to scale, it is shown that the industrial policies will promote capital accumulation, increase saving, and raise welfare of all the trading economies. The effects on the welfare of each country is identical, that is, the industrial policies in one country improve the welfare of all the trading countries to the same degree. This result suggests that by promoting productions with increasing returns to scale, several trading economies may have increased other countries' capital accumulation and welfare each other.

The paper also examines the implications of capital mobility among countries. As the mobility becomes close to perfect, the differences in consumption path between countries shrink. If the capital can move among countries without costs, the consumption paths in two countries become identical. In other words, perfect capital mobility equalizes the consumption between countries.

There are some remaining tasks. In spite of the increasing returns to scale, the equilibrium in this paper does not exhibit endogenous growth. Since the role of the industrial policies is strengthened if we allow for endogenous growth, analyses of economies with endogenous growth may provide further role to industrial policies. Particularly, the framework may help explaining non-convergent growth path among countries.

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APPENDIX

Proof of Proposition 1

Since we consider the long-run effects of industrial policies, we investigate the effects at the steady state, so that we drop the subscript for time, t. Suppose that after the change in the subsidy rate in country A, monopolistically competitive firms in country B conduct their production. The profit for the company is as follows

$$\Pi_B = p_{(i,B)} y_{(i,B)} - r_B K_{(i,B)} - w_B L_{(i,B)}. \tag{1}$$

Let's denote the log-differentiation of a variable, say, $K_{(i,B)}$ as $\widehat{K}_{(i,B)}$. Then, the changes in the profits can be written as

$$d\Pi_B = p_{(i,B)} y_{(i,B)} \left(\widehat{p}_{(i,B)} + \widehat{y}_{(i,B)}\right) - r_B K_{(i,B)} \left(\widehat{r}_B + \widehat{K}_{(i,B)}\right) - w_B L_{(i,B)} \left(\widehat{w}_B + \widehat{L}_{(i,B)}\right). \tag{2}$$

Define the share of the capital costs as follows:

$$a_y = \frac{r_B K_{(i,B)}}{p_{(i,B)} y_{(i,B)}}. \tag{3}$$

Then, using the first order conditions, we can derive

$$\frac{d\Pi_B}{p_{(i,B)} y_{(i,B)}} = \widehat{p}_{(i,B)} + \widehat{y}_{(i,B)} - a_y \widehat{r}_B - (1 - a_y)\, \widehat{w}_B. \tag{4}$$

Similarly, for country A, we can get

$$\frac{d\Pi_A}{p_{(i,A)} y_{(i,A)}} = \widehat{p}_{(i,A)} + \widehat{y}_{(i,A)} - a_y \widehat{r}_A - (1 - a_y)\, \widehat{w}_A + \widehat{T}_A. \tag{5}$$

Using the demand functions, we can show that the ratio of $p_{(i,A)}$ and $p_{(i,B)}$ depends on the ratio of the total supply as follows:

$$\left(\frac{p_{(i,A)}}{p_{(i,B)}}\right)^{-\varepsilon} = \frac{y_{(i,A)}}{y_{(i,B)}}. \tag{6}$$

Since the production scales in the monopolistically competitive firms are constant,[29] we get

$$\widehat{p}_{(i,A)} = \widehat{p}_{(i,B)} \equiv \widehat{p}. \tag{7}$$

At the steady state, the rate of changes in the rental cost is identical to that of the price index in each country,

$$\widehat{r}_s = \widehat{P}, \quad for \quad s = (A, B). \tag{8}$$

In perfectly competitive sector, using the share of the capital costs defined as follows:

$$a_x = \frac{r_s K_{x,s}}{x_s}, \tag{9}$$

we can derive

$$a_x \widehat{r}_s + (1 - a_x) \widehat{w}_s = 0 \quad for \quad s = (A, B). \tag{10}$$

Using (4) and (5) We can eliminate $\widehat{r}_s$ and $\widehat{w}_{,s}$ and get

$$\frac{d\Pi_B}{p_{(i,B)} y_{(i,B)}} = \widehat{p} - \left(\frac{a_y - a_x}{(1 - a_x)} \right) \widehat{P}, \tag{11}$$

and

$$\frac{d\Pi_A}{p_{(i,A)} y_{(i,A)}} = \widehat{p} - \left(\frac{a_y - a_x}{(1 - a_x)} \right) \widehat{P} + \widehat{T}_A. \tag{12}$$

Since $\widehat{T}_A$ is positive, as long as $y_{(i,B)}$ and $y_{(i,A)}$ are positive, the changes in the profits of the firm in country A are greater than that in country B. This contradicts the assumption of free entry and exit. If country B produces the differentiated goods, the profits of the firms should not be negative. However, the free entry and exit in country A decreases the price of the differentiated goods to the level at which the profits in country B become negative. Therefore, in country B, all the monopolistically competitive firms exit from the market.■

[29] $y_{(i,s)}$ is fixed at $(\varepsilon - 1) y_F$ regardless of the level of the subsidy rate. This is a by-product of the specification developed by Dixit and Stiglitz (1977).

The Dynamical System for Two Production Factor Case

Define the Lagrangian for the consumer's problem as follows:

$$\begin{aligned} L &= \sum_{t=0}^{\infty}\left(\frac{1}{1+\rho}\right)^{t} u\left(C_{s,t}\right)+\sum_{t=0}^{\infty}\left(\frac{1}{1+\rho}\right)^{t} \lambda_{s,t}\left(I_{s,t}+(1-\delta) K_{s,t}-K_{s,t+1}\right) \\ &\quad +\sum_{t=0}^{\infty}\left(\frac{1}{1+\rho}\right)^{t} \xi_{s,t}\left(r_{s,t} K_{s,t}+Q_{s,t}\overline{Z}+\Lambda_{s,t}-T_{s,t}-C_{s,t}-P_{t} I_{s,t}\right) \end{aligned} \tag{13}$$

The consumption Euler equation becomes

$$(1+\rho)\lambda_{s,t+1}=\left(\frac{r_{s,t}}{P_t}+1-\delta\right)\lambda_{s,t}, \tag{14}$$

$$\frac{\lambda_{s,t}}{P_t}=u'\left(C_{s,t}\right). \tag{15}$$

In the factor markets, the marginal product values of each production factor should be equalized as follows,

$$T_{s,t}\frac{(\varepsilon-1)}{\varepsilon}p_{(i,s),t}\frac{\partial\widetilde{y}_{(i,s),t}}{\partial K_{(i,s),t}}=\frac{\partial x_{s,t}}{\partial K_{x,s,t}}, \tag{16}$$

$$T_{s,t}\frac{(\varepsilon-1)}{\varepsilon}p_{(i,s),t}\frac{\partial\widetilde{y}_{(i,s),t}}{\partial L_{(i,s),t}}=\frac{\partial x_{s,t}}{\partial L_{x,s,t}}. \tag{17}$$

The market clearing conditions for the factor markets are as follows,

$$n_{s,t}K_{(i,s),t}+K_{x,s,t}=K_{s,t}, \tag{18}$$

$$n_{s,t}L_{(i,s),t}+L_{x,s,t}=\overline{L}. \tag{19}$$

Because of the assumption of free entry and exit, the production level of each differentiated goods are fixed as

$$y_{(i,s)}=(\varepsilon-1)\,y_F. \tag{20}$$

The market clearing condition for the market of each differentiated good takes form as

$$\left(\frac{p_{(i,A),t}}{P_t}\right)^{-\varepsilon}(C_{y,A,t}+C_{y,B,t})=(\varepsilon-1)\,y_F. \tag{21}$$

Because of the national income identity, the budget constraint of each consumer can be written as

$$C_{s,t}+P_tI_{s,t}=n_{s,t}p_{(i,s),t}y_{(i,s),t}+x_{s,t}. \tag{22}$$

The aggregation formula of the price index in the symmetric equilibrium becomes

$$P_t=\left(n_{A,t}p_{(i,A),t}^{1-\varepsilon}+n_{B,t}p_{(i,B),t}^{1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}}. \tag{23}$$

The capital is accumulated as follows:

$$K_{s,t+1}=I_{s,t}+(1-\delta)\,K_{s,t}. \tag{24}$$

Finally, the supply of output should be equal to the amount produced, which implies

$$x_{s,t}=x\left(K_{x,s,t},L_{x,s,t}\right), \tag{25}$$

$$\widetilde{y}_{(i,s),t}=\widetilde{y}\left(K_{(i,s),t},L_{(i,s),t}\right). \tag{26}$$

Define a set of predetermined variables and multipliers as $X_t=(K_{A,t},\lambda_{A,t},K_{B,t},\lambda_{B,t})$. Also, define a set of non-predetermined variables as $W_t=(W_{A,t},W_{B,t},P_t)$, where

$$W_{s,t}=\left(C_{s,t},I_{s,t},x_{s,t},\widetilde{y}_{(i,s),t},K_{x,s,t},L_{x,s,t},K_{(i,s),t},L_{(i,s),t},n_{s,t},p_{(i,s),t}\right). \tag{27}$$

Also define the forcing terms as $Z_t=(T_{A,t},T_{B,t})$

Then, we can take log linearization of the system, which gives us

$$M_{cc}W_t=M_{cs}X_t+M_{ce}Z_t, \tag{28}$$

$$M_{ss0}X_{t+1}+M_{ss1}X_t=M_{sc0}W_{t+1}+M_{sc1}W_t, \tag{29}$$

where M_{cc} : 21 × 21, M_{cs} : 21 × 4, M_{ce}: 21 × 2, M_{ss0} : 4 × 4, M_{ss1} : 4 × 4, M_{sc0} : 4 × 21, M_{sc1} : 4 × 21 matrix, respectively. As long as M_{cc} is invertible, we can eliminate W_t and rewrite the system as follows;

$$P^{-1}X_{t+1} = \Lambda P^{-1}X_t + P^{-1}RZ_{t+1} + P^{-1}QZ_t, \tag{30}$$

where

$$R = \left(M_{ss0} - M_{sc0}M_{cc}^{-1}M_{ce}\right)^{-1}\left(M_{sc0}M_{cc}^{-1}M_{ce}\right), \tag{31}$$

$$Q = \left(M_{ss0} - M_{sc0}M_{cc}^{-1}M_{ce}\right)^{-1}\left(M_{sc1}M_{cc}^{-1}M_{ce}\right), \tag{32}$$

$$P\Lambda P^{-1} = W = -\left(M_{ss0} - M_{sc0}M_{cc}^{-1}M_{ce}\right)^{-1}\left(M_{ss1} - M_{sc1}M_{cc}^{-1}M_{cs}\right). \tag{33}$$

Λ is a diagonal matrix with the eigenvalues of W on its diagonal. P is a matrix whose columns are n linearly independent eigenvectors of W.

Under the parameter values set in the paper, Λ is as follows:

$$\Lambda = \begin{pmatrix} 0.9334 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1.0300 & 0 \\ 0 & 0 & 0 & 1.4767 \end{pmatrix}, \tag{34}$$

which shows that this system contains two unstable roots and one unit root.

Following an algorithm described by Burnside (1997), we can solve the system to obtain policy functions.

Proof of Lemma 1

Define the Lagrangean for the maximization problem for the derivation of the production possibility frontier as follows:[30]

[30] The subscript for time, t, is dropped except for the total capital level because there is no dynamic element in the intratemporal production possibility frontier.

$$L = x\left(K_{x,s}, L_{x,s}\right) + \lambda\left(y_{(i,s)} n_s^{\frac{\varepsilon}{\varepsilon-1}} - const\right) \tag{35}$$

$$+\phi_1\left(\widetilde{y}\left(K_{(i,s)}, L_{(i,s)}\right) - y_F - y_{(i,s)}\right)$$

$$+\phi_2\left(\overline{L} - n_s L_{(i,s)} - L_{x,s}\right) + \phi_3\left(K_t - n_s K_{(i,s)} - K_{x,s}\right)$$

$$+\phi_4\left(\overline{H} - n_s H_{(i,s)} - H_{x,s}\right).$$

Eliminating the multipliers from the first order conditions and applying the Euler's law for homogeneous functions, we can obtain

$$y_{(i,s)} = (\varepsilon - 1)\, y_F, \tag{36}$$

$$\frac{\frac{\partial \widetilde{y}_{(i,s)}}{\partial K_{(i,s)}}}{\frac{\partial \widetilde{y}_{(i,s)}}{\partial L_{(i,s)}}} = \frac{\frac{\partial x_s}{\partial K_s}}{\frac{\partial x_s}{\partial L_s}}, \tag{37}$$

$$\frac{\frac{\partial \widetilde{y}_{(i,s)}}{\partial K_{(i,s)}}}{\frac{\partial \widetilde{y}_{(i,s)}}{\partial H_{(i,s)}}} = \frac{\frac{\partial x_s}{\partial K_s}}{\frac{\partial x_s}{\partial H_s}}. \tag{38}$$

The first equation shows that the production scale of monopolistically competitive firms in the production possibility frontier should be constant at the same level as the market equilibrium level. The second and third equation imply that in the Edgeworth Box for the production factors, two iso-quant curves must touch to each other at the maximum point. The production possibility frontier can be drawn from a system of equations as follows:

$$y_{(i,s)} = (\varepsilon - 1)\, y_F, \tag{39}$$

$$\frac{\frac{\partial \widetilde{y}_{(i,s)}}{\partial K_{(i,s)}}}{\frac{\partial \widetilde{y}_{(i,s)}}{\partial L_{(i,s)}}} = \frac{\frac{\partial x_s}{\partial K_s}}{\frac{\partial x_s}{\partial L_s}}, \tag{40}$$

$$\frac{\frac{\partial \widetilde{y}_{(i,s)}}{\partial K_{(i,s)}}}{\frac{\partial \widetilde{y}_{(i,s)}}{\partial H_{(i,s)}}} = \frac{\frac{\partial x_s}{\partial K_s}}{\frac{\partial x_s}{\partial H_s}}, \tag{41}$$

$$n_s K_{(i,s)} + K_{x,s} = K_{s,t}, \tag{42}$$

$$n_s L_{(i,s)} + L_{x,s} = \overline{L}, \tag{43}$$

$$n_s H_{(i,s)} + H_{x,s} = \overline{L}, \tag{44}$$

$$y_{(i,s)} = \widetilde{y}_{(i,s)} - y_F. \tag{45}$$

Since the market equilibrium contains all the equations that determine the production possibility frontier, under Assumption 1, the market equilibrium is on the frontier.

The Partial Derivatives of the Frontier

The multipliers, λ and $\phi_{3,}$ in the Lagrangean in the previous proof are equivalent to the partial derivatives of the frontier with respect to $y_{(i,s)} n_s^{\frac{\varepsilon}{\varepsilon-1}}$ and K_t, respectively. From the first order conditions, we can get

$$\lambda = n_s^{\frac{-1}{\varepsilon-1}} \frac{\frac{\partial x_s}{\partial K_s}}{\frac{\partial \widetilde{y}_{(i,s)}}{\partial K_{(i,s)}}}. \tag{46}$$

In the market equilibrium, the marginal product revenues of capital in two sectors should be the same, that is,

$$\left(1 - \frac{1}{\varepsilon}\right) p_{(i,s)} \frac{\partial \widetilde{y}_{(i,s)}}{\partial K_{(i,s)}} T_{(i,s),t} = \frac{\partial x_s}{\partial K_{x.s}}. \tag{47}$$

Therefore, in the market equilibrium, λ becomes

$$\lambda = \left(1 - \frac{1}{\varepsilon}\right) p_{(i,s)} T_{(i,s),t} n_s^{\frac{1}{2-\varepsilon}}. \tag{48}$$

Similarly, we can derive

$$\phi_3 = \frac{\partial x_s}{\partial K_{x,s}}. \tag{49}$$

■

Proof of Proposition 2

Denote the log-differentiation of each variable as follows:

$$\widehat{x}_s = \frac{dx_s}{x_s}. \tag{50}$$

Then, the changes in welfare of country s can be written as[31]

$$\begin{aligned} dU_s &= \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho} \right) C_{s,t} \frac{du\left(C_{s,t}\right)}{dC_{s,t}} \left(\widehat{C}_{s,t} \right) \\ &= \overline{C} u' \left(\overline{C} \right) \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho} \right)^t \left(\widehat{C}_{s,t} \right). \end{aligned} \tag{51}$$

From the budget constraint, we can get

$$\widehat{C}_{s,t} = \widehat{x}_{s,t} + \frac{np_i y_i}{x} \left(\widehat{n}_{s,t} + \widehat{p}_{(i,s),t} \right) - \frac{np_i y_i}{x} \left(\widehat{C}_{y,s,t} + \widehat{P}_t \right). \tag{52}$$

Using the formula for capital accumulation, $\widehat{C}_{y,s,t}$ can be written as a function of capital,

$$\widehat{C}_{y,s,t} = \frac{1}{\delta} \widehat{K}_{s,t+1} - \left(\frac{1-\delta}{\delta} \right) \widehat{K}_{s,t}. \tag{53}$$

Plugging (52) and (53) into the changes in the utility, we can get[32]

$$\begin{aligned} dU_s &= \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho} \right)^t \left(\widehat{x}_{s,t} + \frac{np_i y_i}{x} \widehat{n}_{s,t} + \frac{np_i y_i}{x} \left(\widehat{p}_{(i,s),t} - \widehat{P}_t \right) \right) \\ &\quad - \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho} \right)^t \frac{np_i y_i}{x} \left(\frac{1}{\delta} \widehat{K}_{s,t+1} - \left(\frac{1-\delta}{\delta} \right) \widehat{K}_{s,t} \right). \end{aligned} \tag{54}$$

Using Lemma 2 and the fact, $\widehat{K}_{s,0} = 0$, we can rewrite the above formula as follows:

[31] Notice that we use the linear approximation at the steady state for evaluating the changes in the utility level.

[32] I use the fact that the production scale, $y_{(i,s),t}$ does not change over time, so that $\widehat{y}_{(i,s),t} = 0$.

$$dU_s = \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho}\right)^t \left(\frac{np_i y_i}{x}\left(\widehat{p}_{(i,s),t} - \widehat{P}_t\right)\right) \tag{55a}$$

$$+ \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho}\right)^t \left(\widehat{x}_{s,t} + \frac{np_i y_i}{x}\widehat{n}_{s,t} - \frac{np_i y_i}{x}\left(\frac{\rho+\delta}{\delta}\right)\widehat{K}_{s,t}\right) \tag{55b}$$

$$= \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho}\right)^t \left(\frac{npy}{x}\left(\widehat{p}_{(i,s),t} - \widehat{P}_t\right)\right) \tag{55c}$$

$$+ \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho}\right)^t \left(\frac{\Phi_1}{x}\left(\frac{\varepsilon-1}{\varepsilon}\right) n_s^{\frac{\varepsilon}{\varepsilon-1}} y_i \widehat{n}_{s,t} + \frac{\frac{\partial x}{\partial K_x}K}{x}\widehat{K}_{s,t}\right) \tag{55d}$$

$$+ \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho}\right)^t \left(\frac{np_i y_i}{x}\widehat{n}_{s,t} - \frac{np_i y_i}{x}\left(\frac{\rho+\delta}{\delta}\right)\widehat{K}_{s,t}\right) \tag{55e}$$

$$= \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho}\right)^t \left(\frac{np_i y_i}{x}\left(\widehat{p}_{(i,s),t} - \widehat{P}_t\right)\right) \tag{55f}$$

$$+ \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho}\right)^t \left(\frac{np_i y_i}{x}\widehat{n}_{s,t} - \frac{np_i y_i}{x}\widehat{n}_{s,t}\right) \tag{55g}$$

$$+ \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho}\right)^t \left(\frac{np_i y_i}{x}\left(\frac{\rho+\delta}{\delta}\right)\widehat{K}_{s,t} - \frac{np_i y_i}{x}\left(\frac{\rho+\delta}{\delta}\right)\widehat{K}_{s,t}\right) \tag{55h}$$

$$= \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho}\right)^t \left(\frac{np_i y_i}{x}\left(\widehat{p}_{(i,s),t} - \widehat{P}_t\right)\right). \tag{55i}$$

From the market clearing conditions for the commodities produced by monopolistic firms, we can derive

$$\frac{y_{(i,A),t}}{y_{(i,B),t}} = \left(\frac{p_{(i,A),t}}{p_{(i,B)},t}\right)^{-\varepsilon}. \tag{56}$$

Because both production scales are constant, we get

$$\widehat{p}_{(i,A),t} = \widehat{p}_{(i,B),t} \equiv \widehat{p}_t. \tag{57}$$

In other words, the price changes are identical in both countries. Then, the changes in the welfare of country s becomes

$$dU_s = \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho}\right)^t \left(\frac{np_i y_i}{x}\left(\widehat{p}_t - \widehat{P}_t\right)\right). \tag{58}$$

The right hand side does not include the country index s, which means the changes in the welfare of each country are identical. ■

Proof of Proposition 3

First, we show that the effects of the industrial policies on the welfare of both countries are identical.

In the equilibrium, the budget constraint can be written as

$$C_{s,t} + P_t I_{s,t} = n_{s,t} p_{(i,s),t} y_{(i,s),t} + x_{s,t} + r_{s,t}\left(K_{s,s,t} - K_{s,t}\right) + r_{s',t} K_{s,s',t}, \tag{59}$$

where s' stands for the other country. $K_{s,s,t}$ is the amount of domestic capital owned by the domestic consumer. $I_{s,t}$ can be divided as

$$I_{s,t} = V_{s,s,t} + V_{s,s',t}. \tag{60}$$

The changes in balances can be written as

$$K_{s,s,t+1} = V_{s,s,t} + (1-\delta) K_{s,s,t}, \tag{61}$$

$$K_{s,s\prime,t+1} = V_{s,s\prime,t} + (1-\delta) K_{s,s',t}. \tag{62}$$

Then, we can proceed exactly the same as in the previous proof so that we get

$$dU_s = \sum_{t=0}^{\infty}\left(\frac{1}{1+\rho}\right)^t \left(\frac{np_i y_i}{x}\left(\widehat{p_t} - \widehat{P_t}\right)\right). \tag{63}$$

Again, the right hand side does not include the country index s, which means the changes in the welfare of each country are identical.

Next, we show that the rate of changes of consumption at time $t > 2$ are identical in both countries. It is easy to show because the free capital mobility makes the rental costs of capital of each country be identical. The consumption Euler equation can be written as

$$(1+\rho)\,\lambda_{s,t+1} = \left(\frac{r_{s,t}}{P_t} + 1 - \delta\right)\lambda_{s,t}, \tag{64}$$

$$\frac{\lambda_{s,t}}{P_t} = u'\left(C_{s,t}\right). \tag{65}$$

Therefore, as long as the rental costs of capital, $r_{s,t}$, are identical, the rates of change of consumption are identical, too.

The last step is to show the identity of the changes in consumption at the first period. Since we have already seen that the new consumption paths give the same utility level to the consumer in each country, given the fact that the rates of change in consumption are identical in both countries, the initial changes in the consumption should also be identical. ■

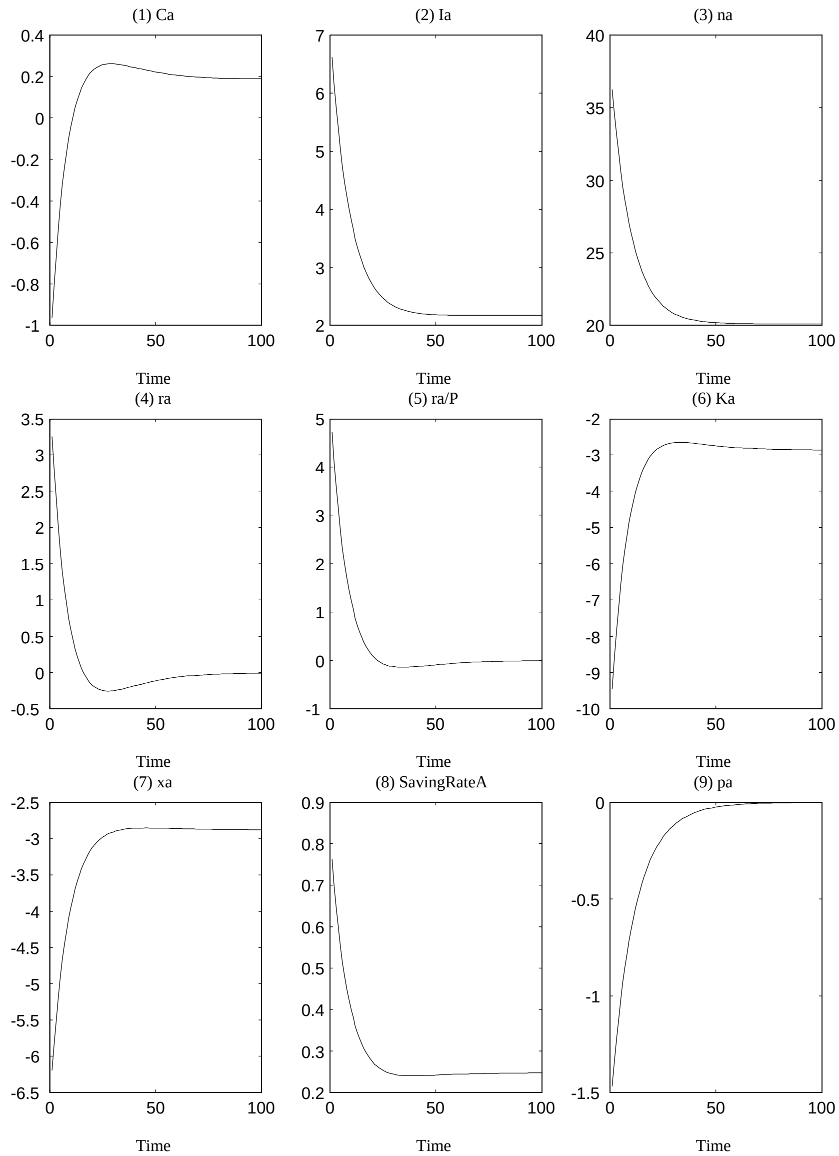

Fig. 1. Impulse-Responses in Country A with Two Production Factors

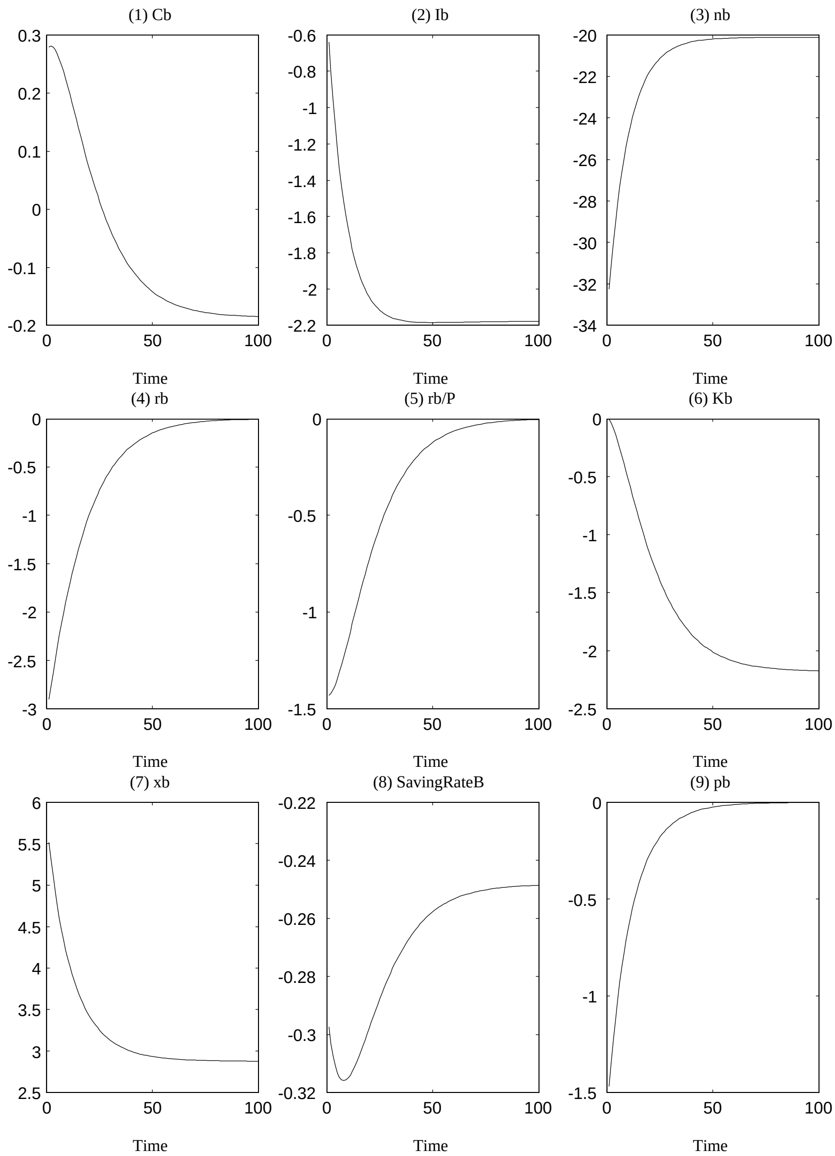

Fig. 2. Impulse-Responses in Country B with Two Production Factors

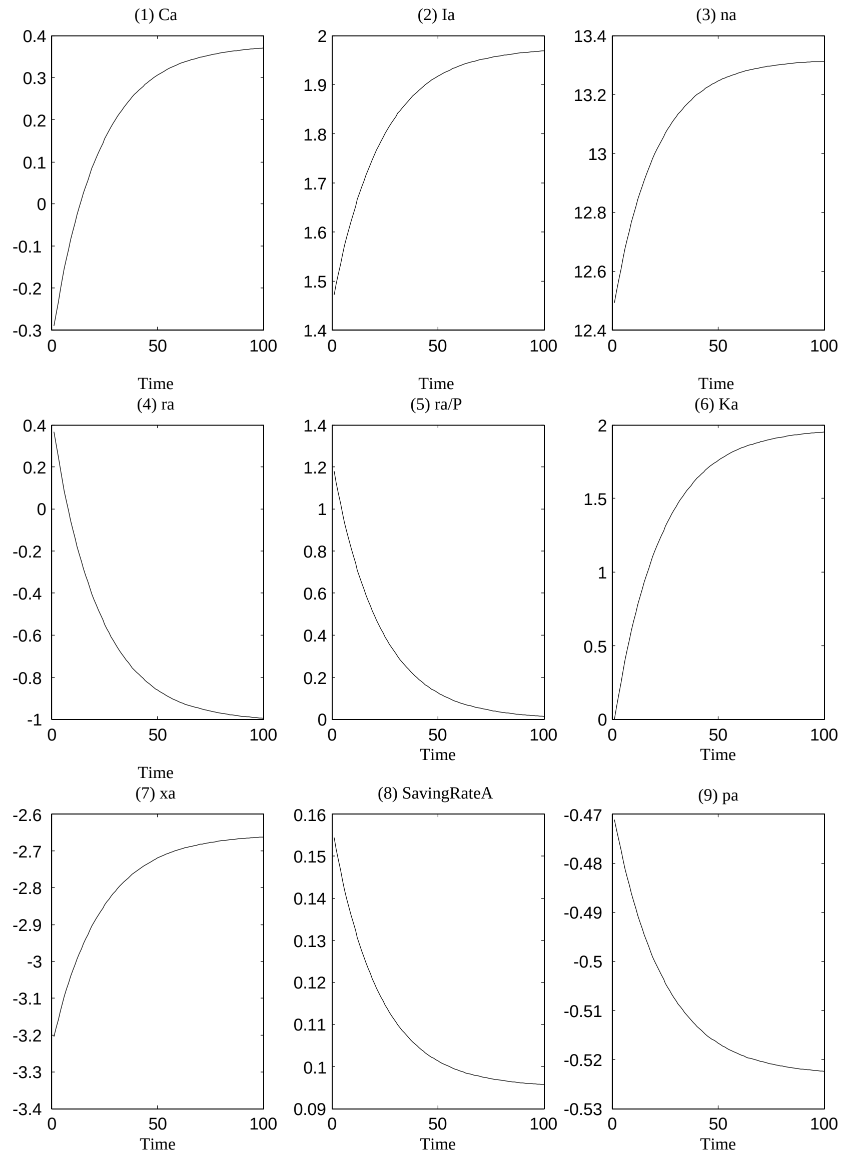

FIG. 3. Impulse-Responses in Country A with Three Production Factors

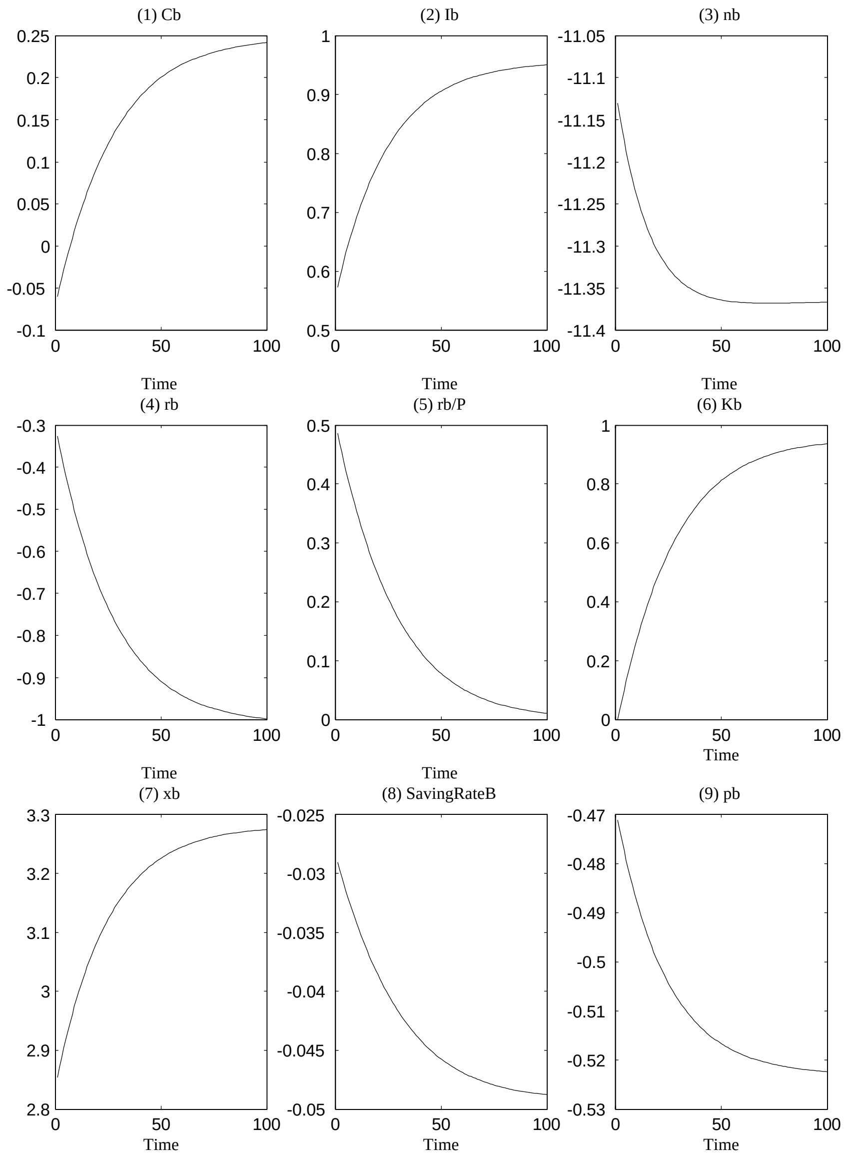

FIG. 4. Impulse-Responses in Country B with Three Production Factors

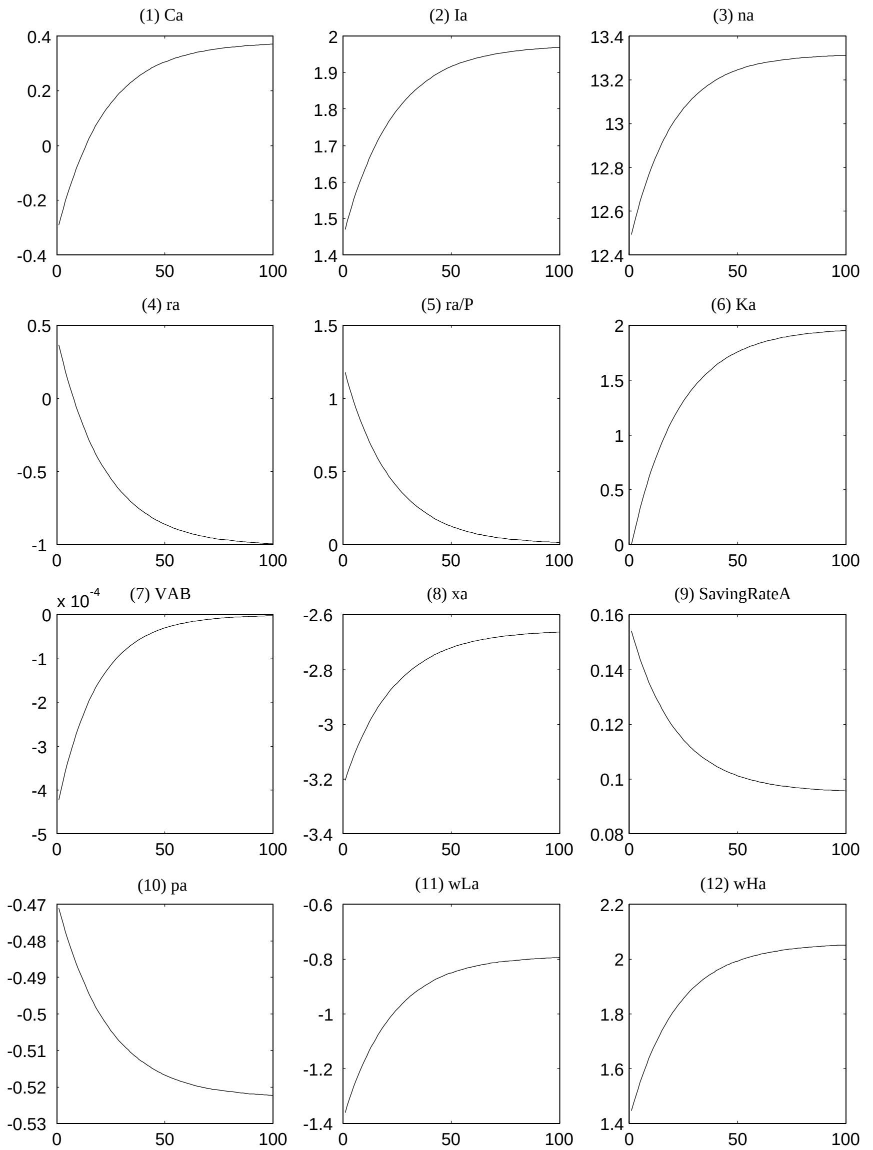

FIG. 5. Impulse-Responses in Country A When Capital Move, Z = 1000.

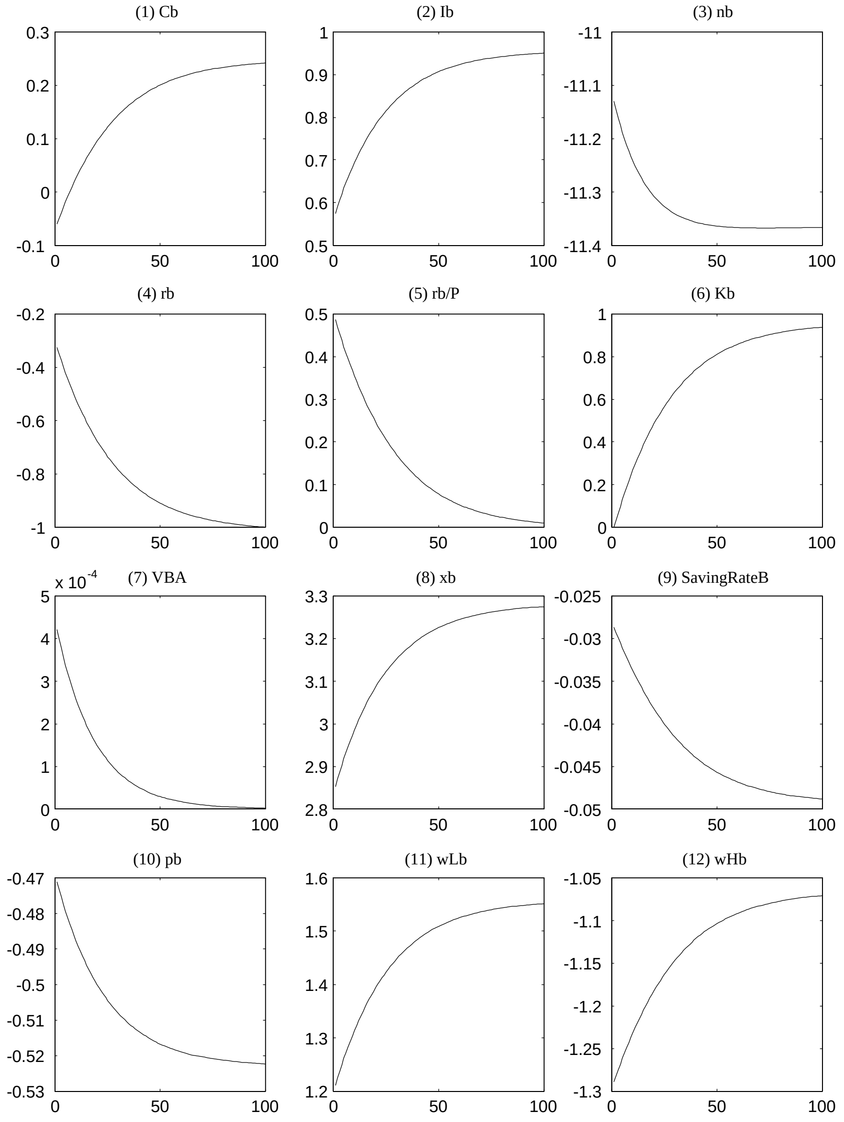

FIG. 6. Impulse-Responses in Country B When Capital Move, Z = 1000.

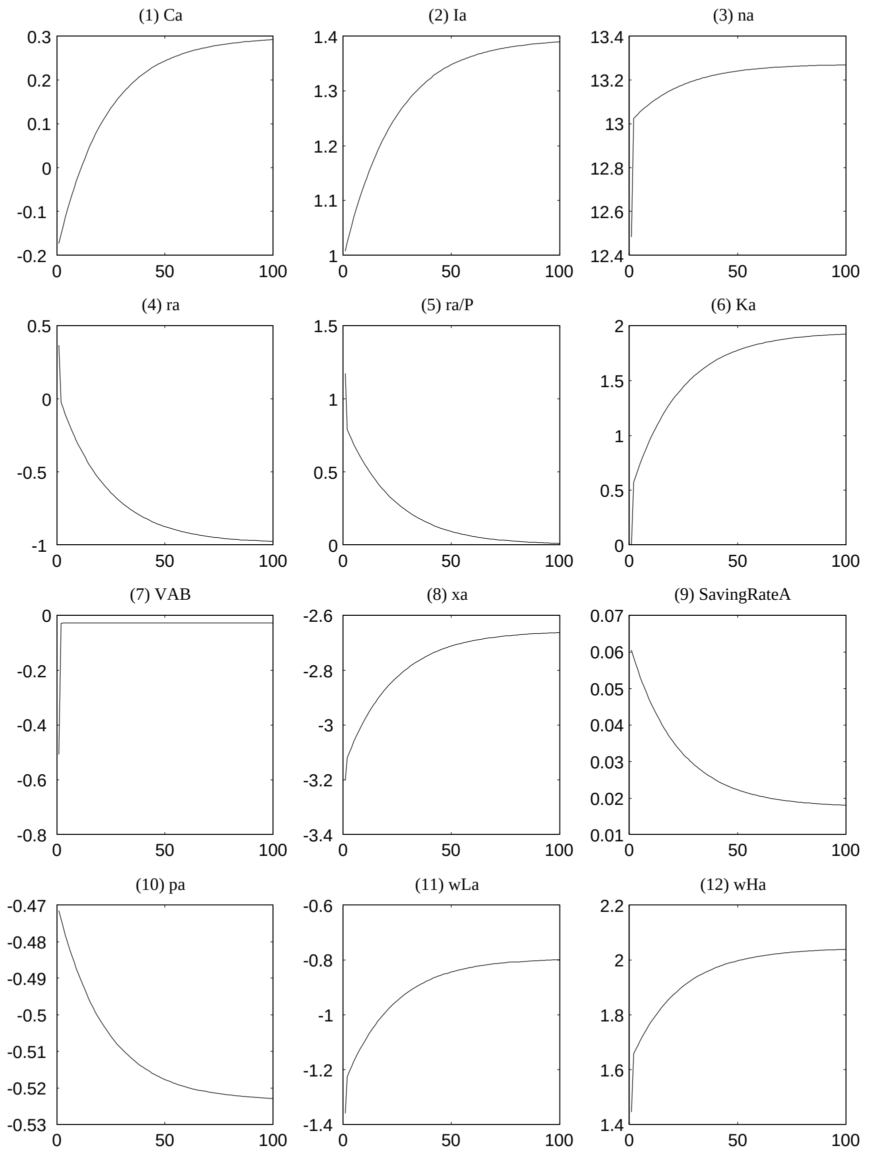

FIG. 7. Impulse-Responses in Country A When Capital Move, Z = 0.000001.

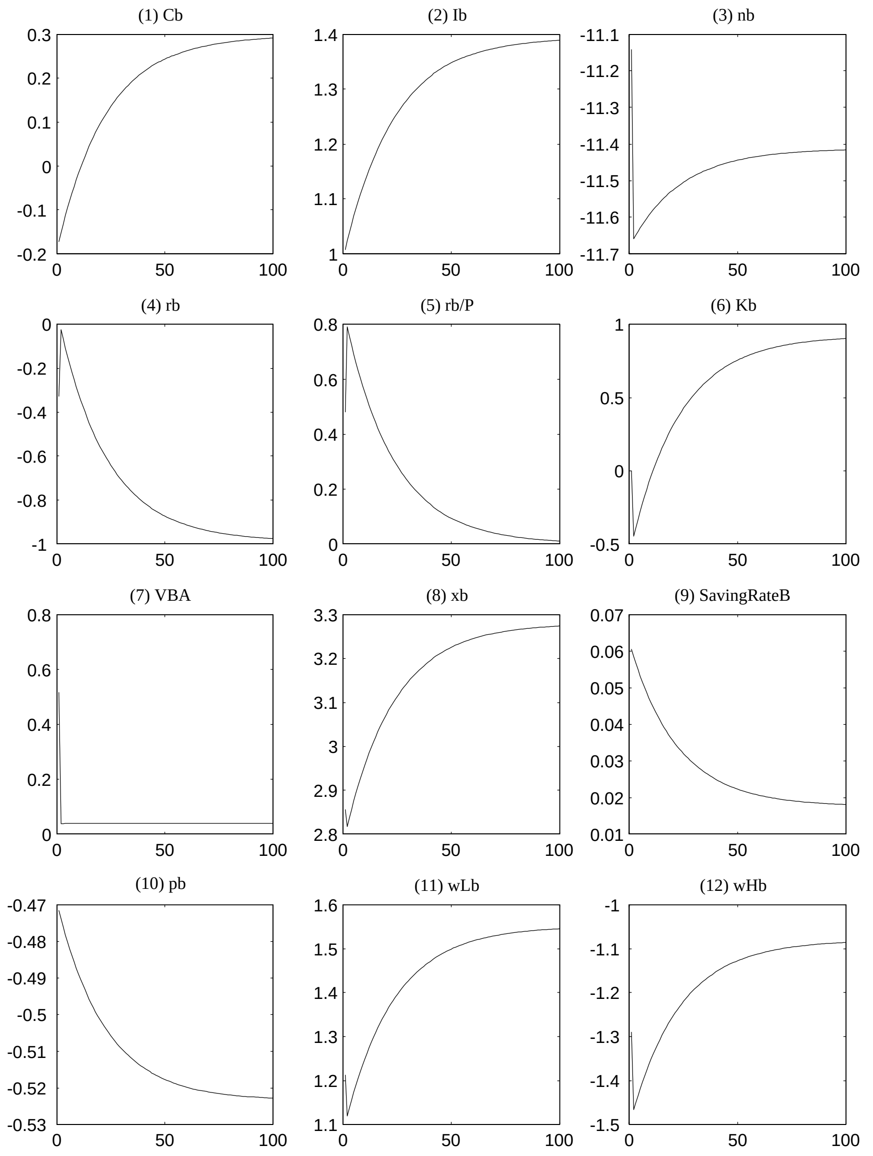

FIG. 8. Impulse-Responses in Country B When Capital Move, Z = 0.000001.